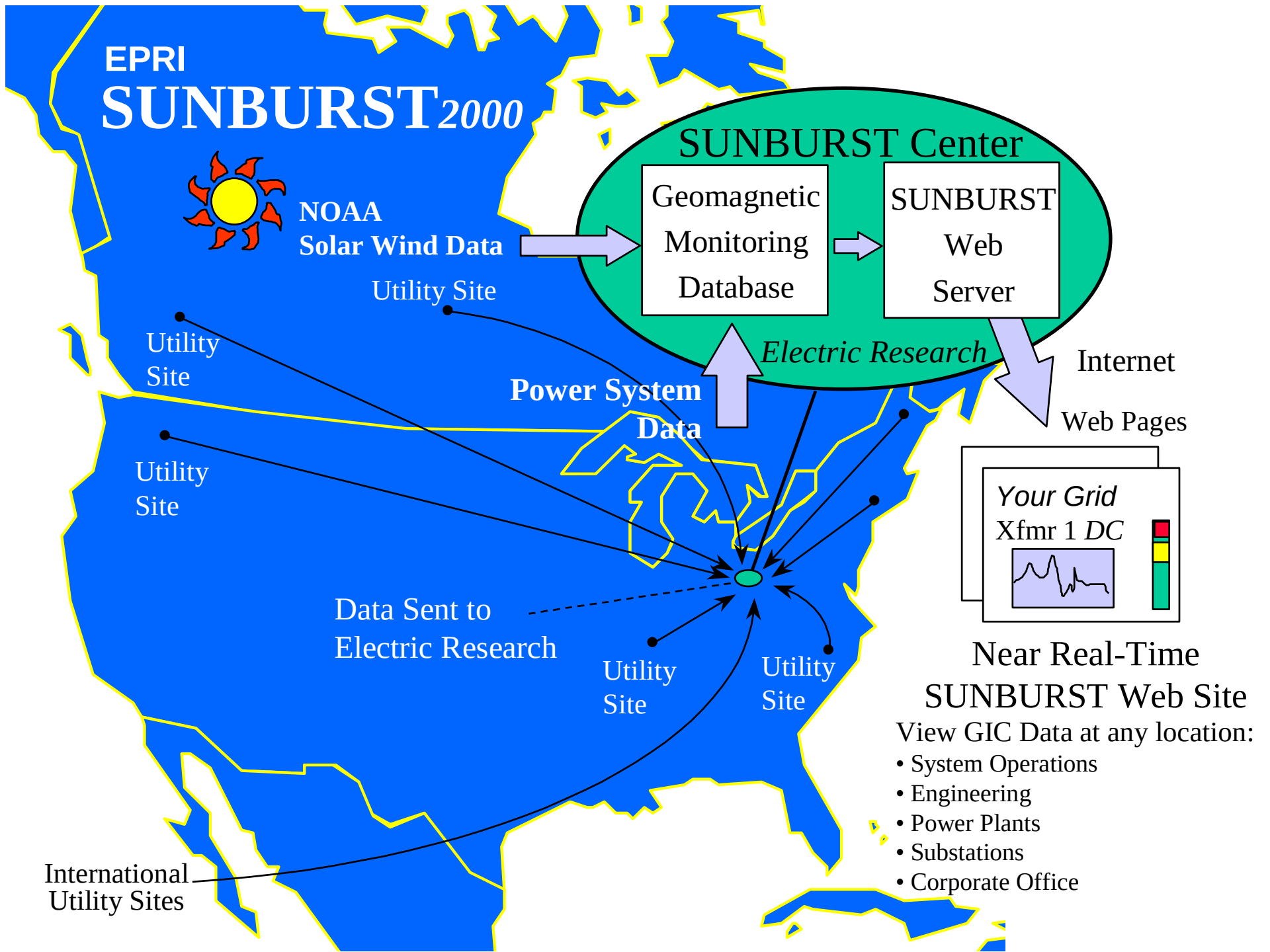
EPRI | ELECTRIC POWER RESEARCH INSTITUTE

EPRI SUNBURST Network Geomagnetic Disturbance Workshop
8/27/13

Background

- March 1989 solar storm creates awareness.
- EPRI Conference on GICs held in November 1989.
- SUNBURST Project started in 1990 to detect and monitor GICs.
- First generation dial-up system providing GIC data began reporting data in 1990, on back end of solar cycle 22.
- Second generation SUNBURST system was a near real-time Internet connected system (solar cycle 23).
- Simplified wireless node for GIC monitoring (solar cycle 24).

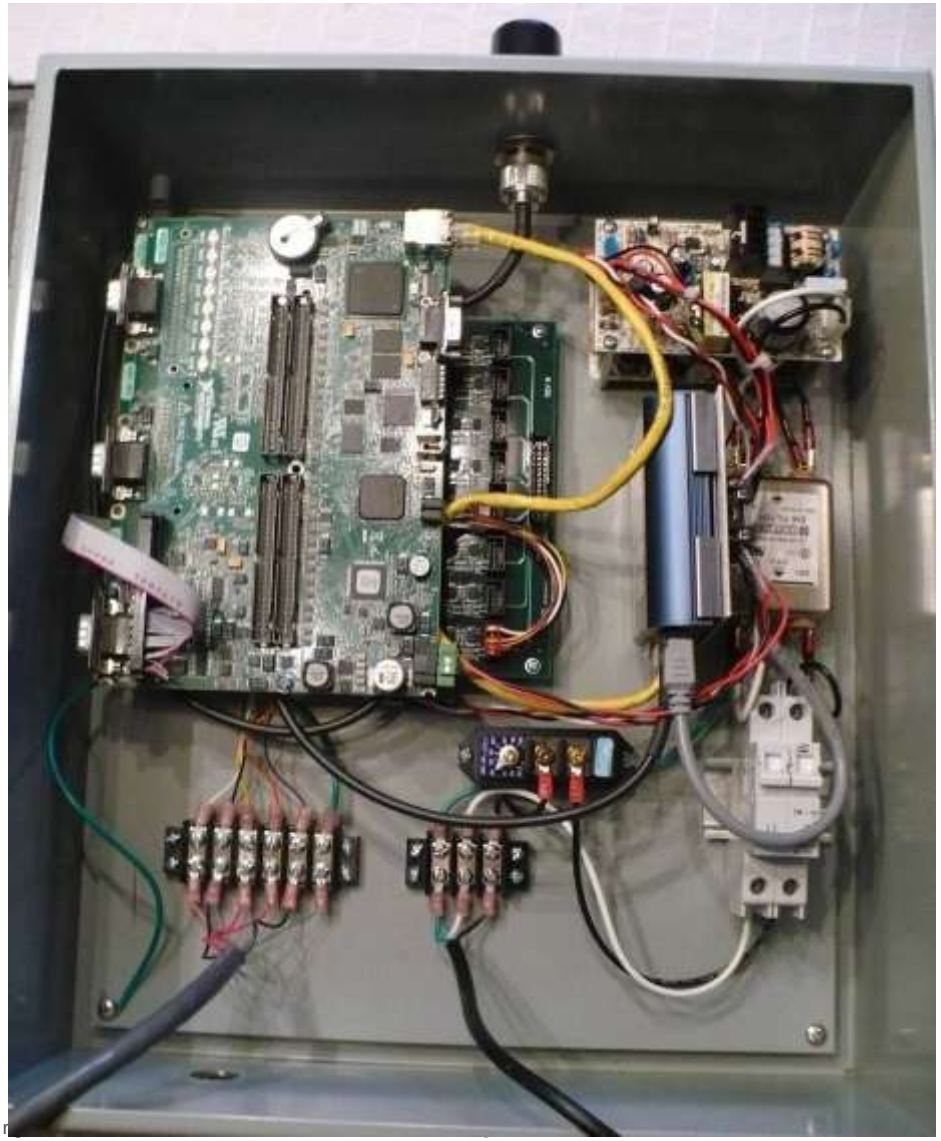

EPRI
SUNBURST2000
NOAA
Solar Wind Data
SUNBURST Center
Geomagnetic Monitoring Database
SUNBURST Web Server
Electric Research
Internet
Web Pages
Utility Site
Utility Site
Utility Site
Power System Data
Your Grid
Xfmr 1 DC
Data Sent to Electric Research
Utility Site
Utility Site
International Utility Sites
Near Real-Time SUNBURST Web Site
View GIC Data at any location:
• System Operations
• Engineering
• Power Plants
• Substations
• Corporate Office

New Wireless SUNBURST Nodes

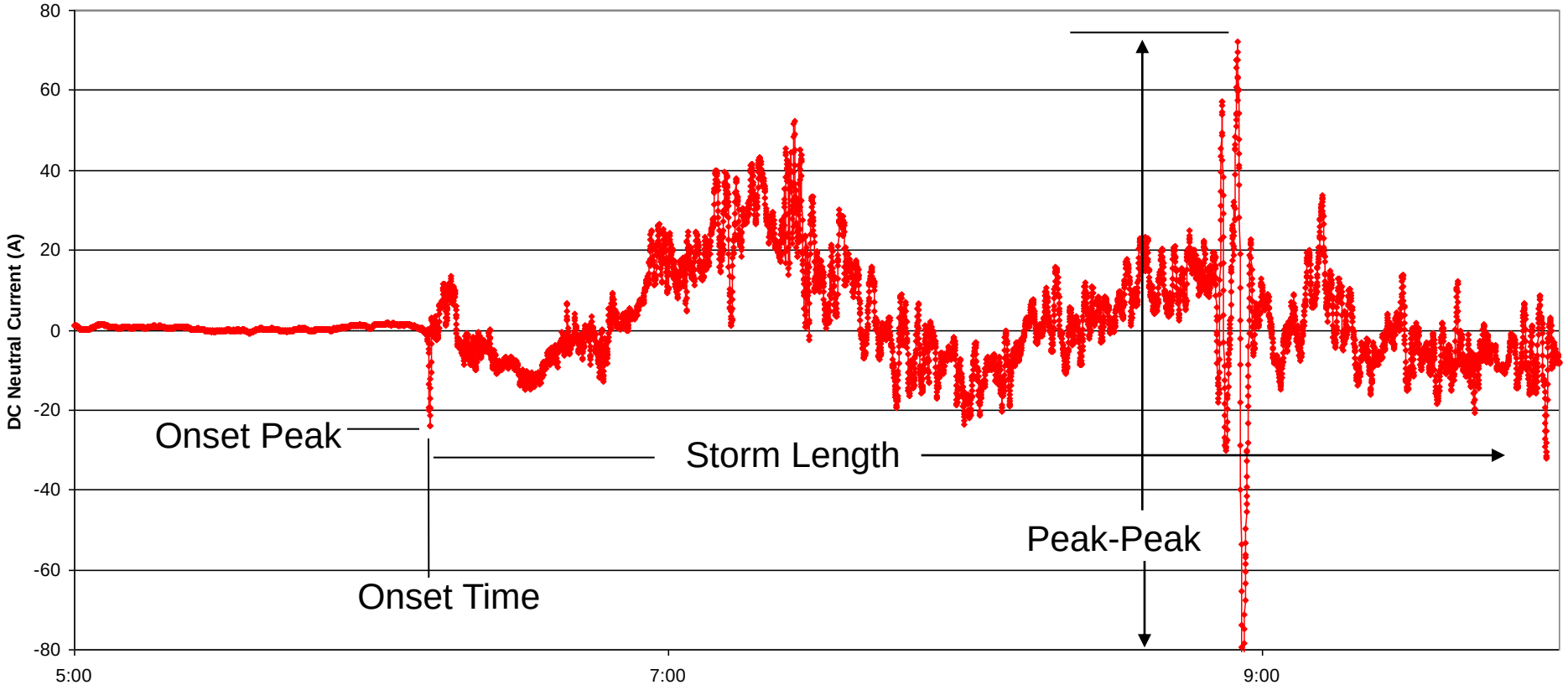
- Relatively easy to install.
- Built using mostly off-the-shelf components.
  - Only custom part is a signal conditioning card.
  - Likely that we will be able to support and repair these devices far into the future.
- Communication with SUNBURST server through the public cellular network.
- Cellular modem includes a robust firewall to protect the device.
- Does not use the utility's IT infrastructure in any way.
- Software is remotely upgradeable.

Sioux City #2

New Wireless SUNBURST Nodes



Event Example: October 29, 2003



GIC Measurement an Important Element of the Project

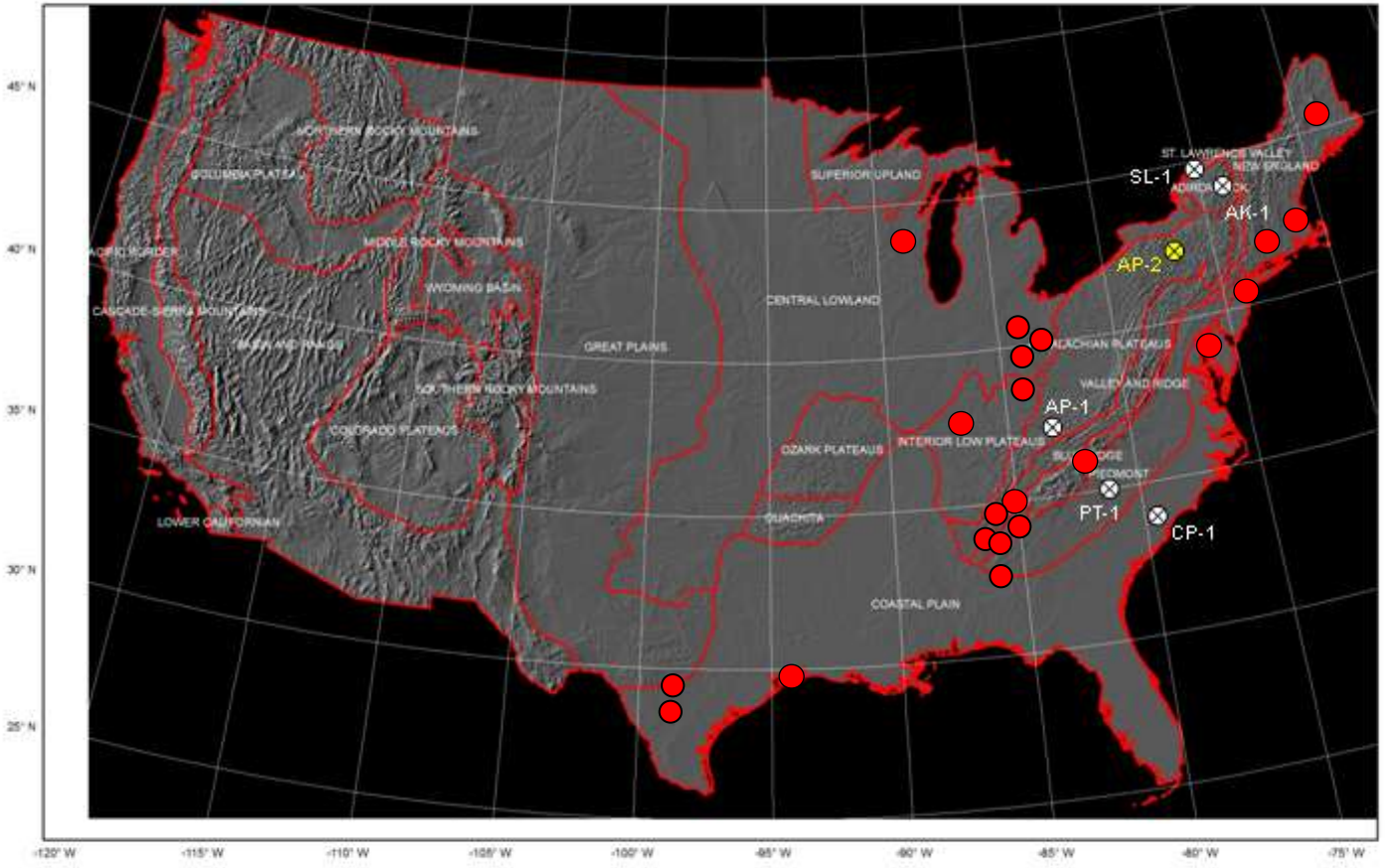
- Crucial to validate the predictions of GIC events
- Improve our understanding of GIC and *geology*
- Improve our understanding of GIC and *latitude*
- Determine the effectiveness of blocking devices
- Data *can* be made available
  - Narrow the request
  - Requires host approval
- *Can be used in system operations… however*

DOE has Joined the GMD Project to Support Wide Area Measurement in US and North America

- Expanding Sunburst Node System
- Add new Sunburst Nodes where needed
- Integrate non-Sunburst GIC nodes
- Exploring addition of variometers to help with modeling
  - Add refinement to six magnetometers
  - Helps eliminate error sources between measured and calculated GIC

Existing Sunburst Nodes

Location of 1D Earth Resistivity Models
with respect to Physiographic Regions of the USA

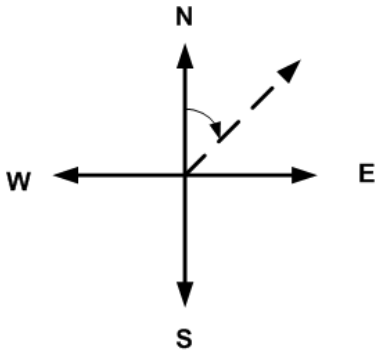


Geomagnetic Storm Scenario

- An assumed uniform geoelectric field was used to determine the induced voltage in the transmission lines and resulting GIC flows.
  - Detailed Earth conductivity models were not available at the time of study
  - For the purpose of the analysis it's a reasonable approximation
  - Electric field and consequently GICs can be scaled based on historical event data
- The peak magnitude of the geoelectric field resulting from the 1989 storm was approximately 1.7 V/km (2.7 V/mile).
  - 2.0 V/km (with varying direction) geoelectric field was used to compute GIC flows in this study.

Steps

- A uniform geoelectric field of magnitude 2V/km with direction varying from 0 to 180 degrees was used
  - The North direction was assumed as point of reference.
  - The field was varied with increments of 15 degrees.

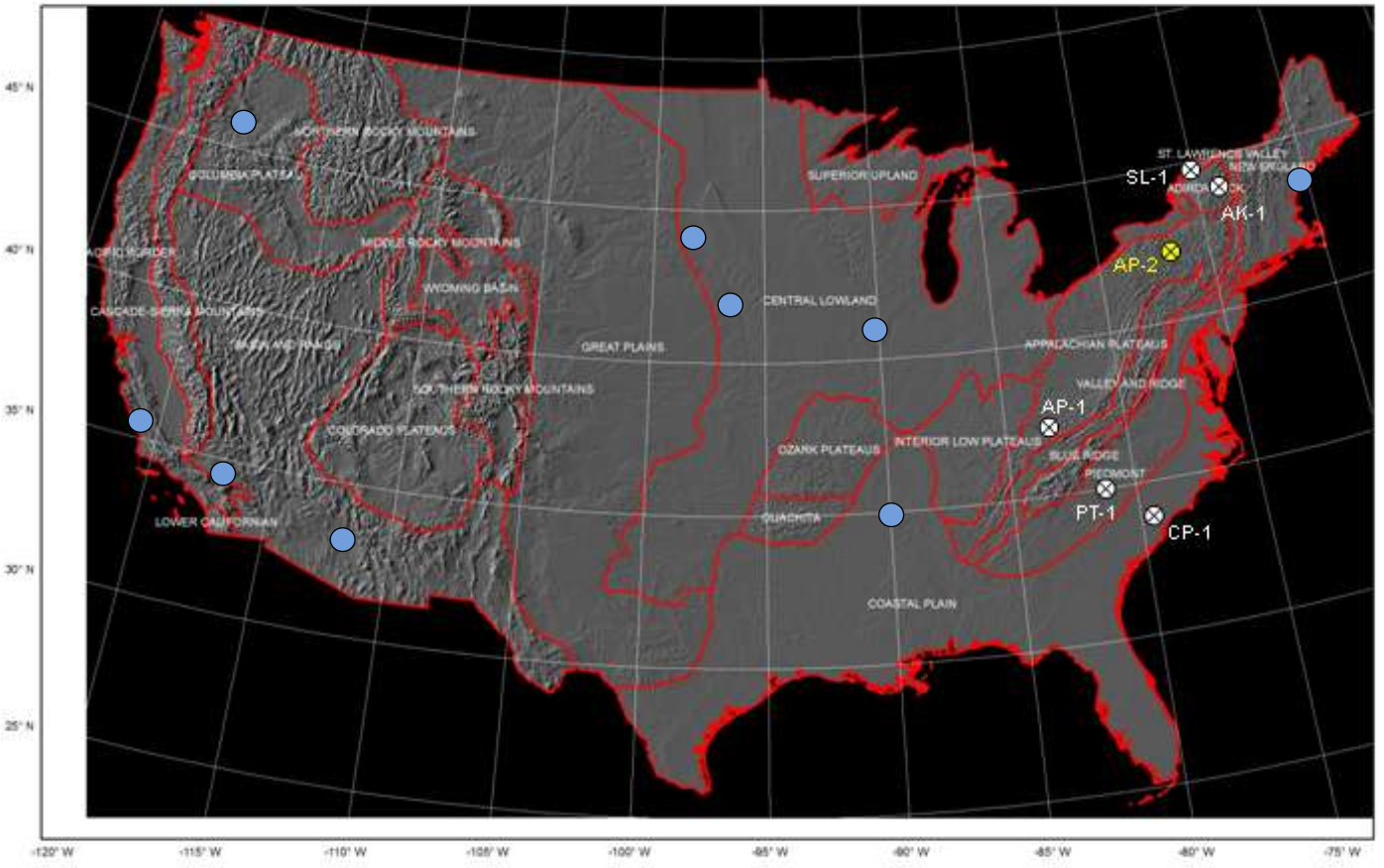


- The GIC module of the PowerWorld was used to calculate:
  - The induced DC voltages in the transmission lines and,
    - Line voltages depend on the direction
    - Lat and Long info is used to calculate direction
  - Consequently, the GIC flows in the network model.

- The magnitude of the highest GIC flows in the Xfmr neutral for any field direction is calculated

Candidate Nodes

Location of 1D Earth Resistivity Models
with respect to Physiographic Regions of the USA



Scaled GIC Values : All Regions

The tables shows 10 nodes with highest GIC values over the WECC and Eastern Interconnect

Substation Name	Latitude	Longitude	Transformer					GIC (Amps) Uniform Field (2V/km)	Scaling Factor	GIC (Amps) 1/100 Storm Wavefront	Field Direction (Degree)	Area	Nerc Region
			From Bus kV	From Bus Name	To Bus kV	To Bus Name	Ckt						
Broadland	44.5	-98.4	345.00	BRDLAND3	345.00	BRDLNDTY	1.00	259.28	0.19	49.26	135.00	WAPA	MRO
Victorville	34.6	-117.3	500.00	VICTORVL	287.00	VICTORVL	1.00	324.86	0.15	48.73	60.00	LADWP	WECC
Diablo Canyon	35.2	-120.8	25.00	DIABLO 2	500.00	DIABLO	1.00	307.97	0.15	46.20	60.00	PG&E	WECC
Ashe	46.5	-119.3	500.00	ASHE	25.00	CGS	1.00	303.80	0.15	45.57	75.00	NW	WECC
Oak Grove	41.1	-90.4	345.00	OAKGROV3	161.00	OAKGROV5	1.00	254.39	0.17	44.51	165.00	MEC	MRO
Sioux City #2	42.6	-96.3	115.00	SIOUXFL7	1.00	SIOUXSTR	1.00	246.19	0.19	46.78	165.00	WAPA	MRO
Pinal West	33.0	-112.2	500.00	PINAL_W	345.00	PINALWES	1.00	282.66	0.15	42.40	165.00	AZ	WECC
Surowiec	43.9	-70.2	345.00	SUROWIEC	99.00	SUROWIEC T1	1.00	211.75	0.20	42.35	15.00	ISO-NE	NPPC
Westwing	33.7	-112.3	345.00	WESTWING	100.00	WW.3WP	1.00	282.33	0.15	42.35	0.00	AZ	WECC
Freeport	35.0	-90.0	500.00	8FREEPORT TN	161.00	5FREEPORT TN	1.00	280.28	0.15	42.04	45.00	TVA	SERC

Selection Criteria

- Anticipated GIC Activity
- Areas with few Sunburst Nodes
- Noteworthy sites (TMI, Salem/Hope Creek)
- Host interest

Status

- Victorville installed
- Sioux City installed
- Snowdoun in progress
- Oak Grove in progress
- Silver King (SRP) in progress
- LaCygne Generator Step-Up #1 KCPL in progress

Magnetometer Locations

Location of 1D Earth Resistivity Models
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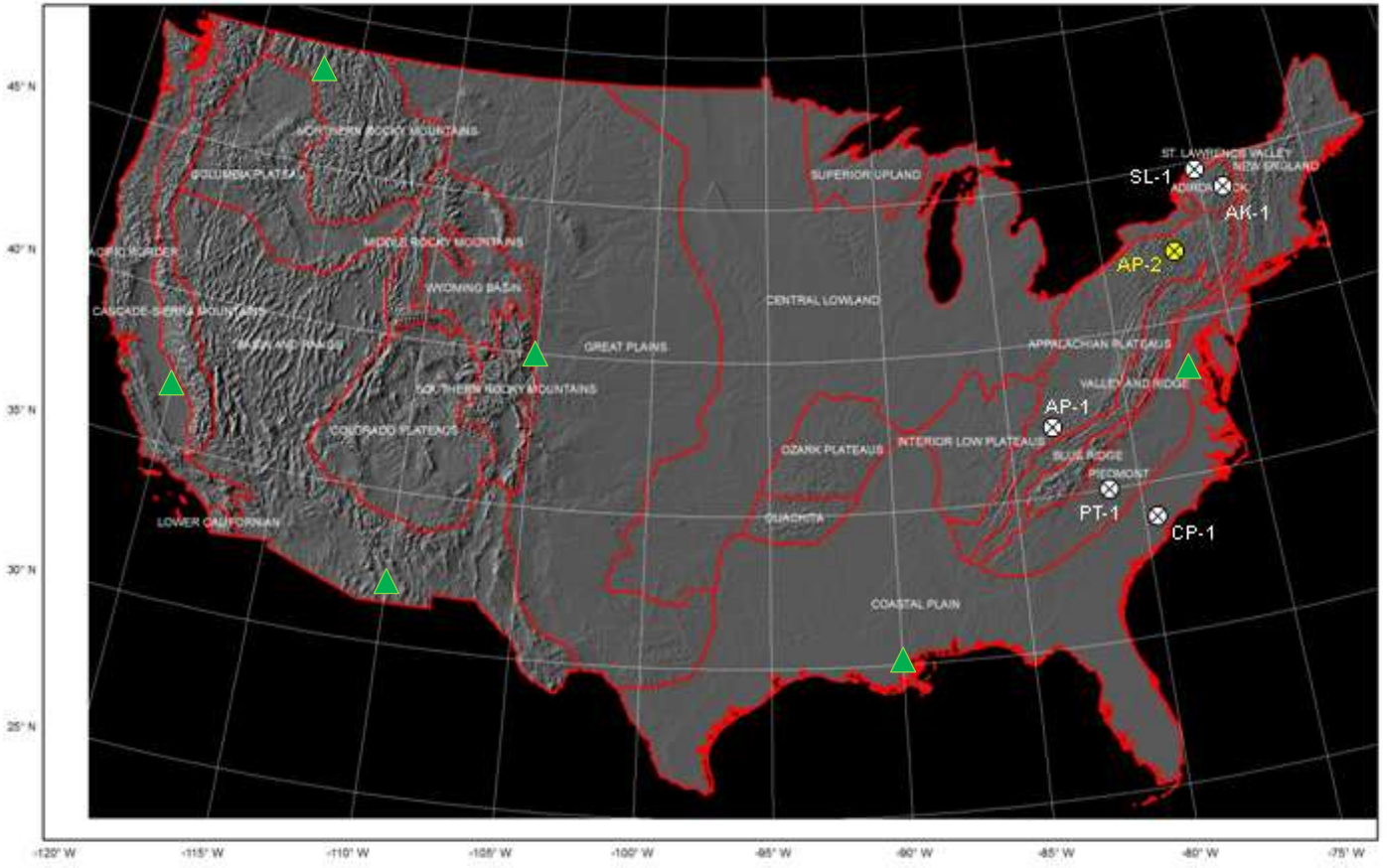
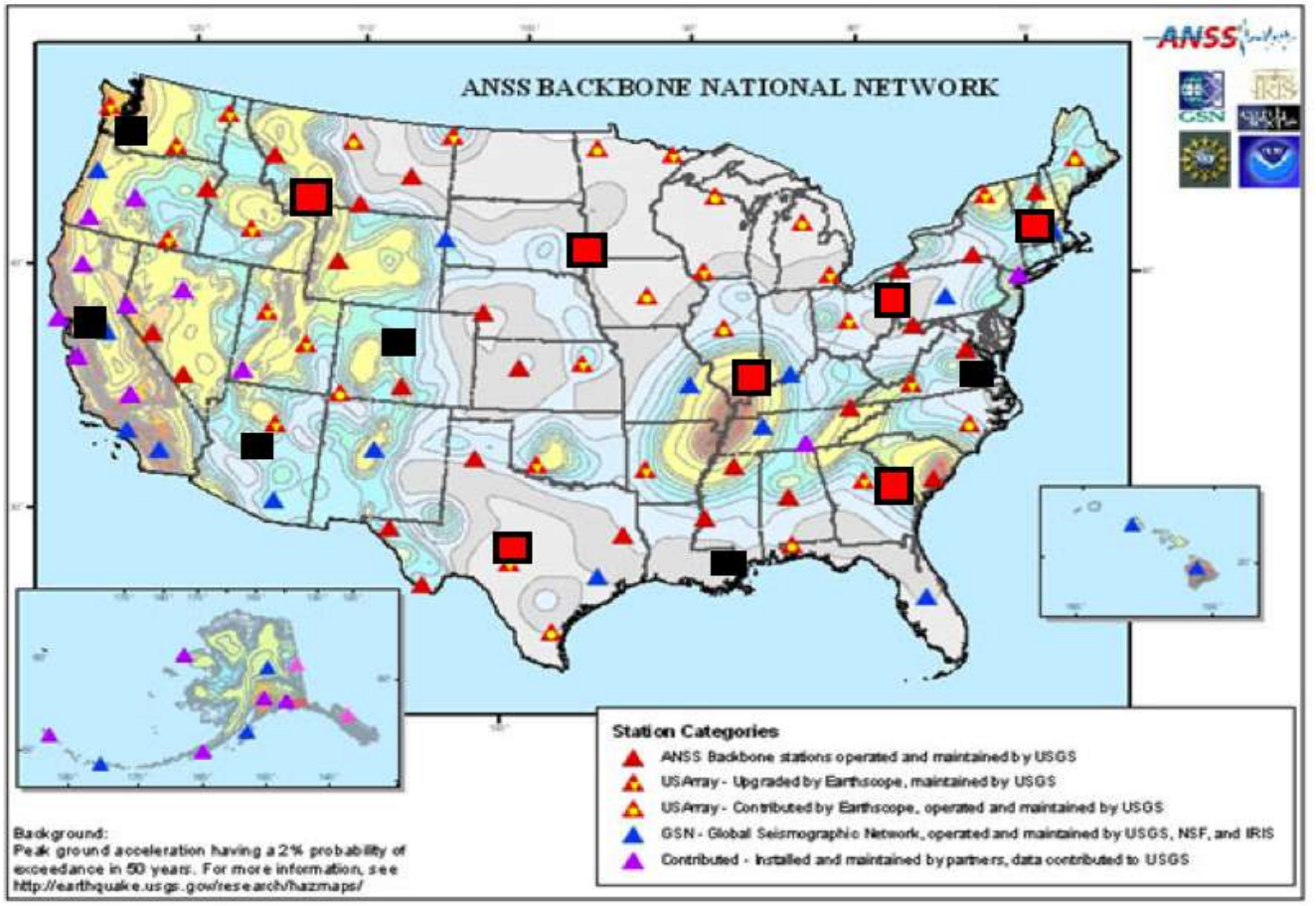


Integration of Magnetometer / Variometer data Instrumentation

- To meet user needs, the magnetometer must:
- Provide vector magnetic field measurements
- Allow a 1-second time resolution
- Have reasonable baseline drift and temperature stability
- Require minimum manual intervention
- UCLA fluxgate mag (used in well-developed science applications, would possibly require modification of data acquisition processes), ~$10 - $15k

Site Location

Map below shows existing USGS observatories as black squares. Red squares showed proposed locations for variation instrument installation. Our suggestion is to begin with a site near St. Louis, or elsewhere in the mid-west, to address the largest gap in existing coverage.



Together…Shaping the Future of Electricity